

7 P.

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-018606
 (43)Date of publication of application : 22.01.2002

(51)Int.Cl. B23B 27/14
 B23C 5/16
 C23C 14/06

(21)Application number : 2000-200206
 (22)Date of filing : 30.06.2000

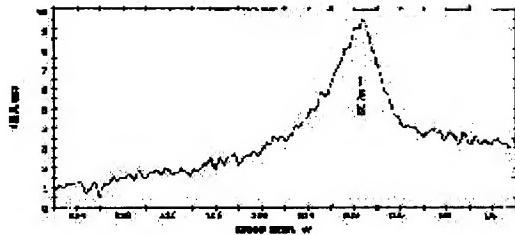
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(54) COATED CUTTING TOOL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a coated cutting tool employing adhesion resistant coat which prevents the coat peeling or breaking which is caused by heat crack due to extremely deteriorated heat crack resistance and the heat crack in wet cutting by restraining an increase in the friction resistance caused by adhesion and deposition to a workpiece.

SOLUTION: In a coated cutting tool comprising a coat of a single layer or multiple layers coated on a cutting tool base body, at least one layer of the coated layer is made of chemical composition expressed by $(\text{Cr}_{1-a}\text{Si}_a)(\text{N}_x\text{B}_{1-x})$, wherein $0.7 \leq a < 1$, $0.4 \leq x \leq 1$, and a CrSi film including the nitride phase of Si and/or nitride phase of B.



LEGAL STATUS

[Date of request for examination] 07.05.2001
 [Date of sending the examiner's decision of rejection]
 [Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
 [Date of final disposal for application]
 [Patent number] 3394021
 [Date of registration] 31.01.2003
 [Number of appeal against examiner's decision of rejection]
 [Date of requesting appeal against examiner's decision of rejection]
 [Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] the covering cutting tool which covered the enveloping layer which becomes a cutting-tool base from one layer or a multilayer -- setting -- at least one layer ($NxB\ 1-x$ ($CraSi1-a$)) of this enveloping layer -- however, the covering cutting tool characterized by being the CrSi system film which comes out, and consists of $0.7 < a < 1$, $0.4 \leq x \leq 1$, and chemical composition shown, and contains the nitride phase of Si, and/or the nitride phase of B.

[Claim 2] It is the covering cutting tool characterized by being the TiAl system film with which at least one layer of this enveloping layer contains N at least as a nonmetallic element in a covering cutting tool according to claim 1 including Ti and aluminum as a metallic element.

[Claim 3] The covering cutting tool characterized by the values of dT/dC being 0.98 or more and 1.02 or less when the lattice constant computed from the X diffraction of each (111) field of this TiAl system film and this CrSi system film is set to dT and dC in a covering cutting tool according to claim 2, respectively.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the covering cutting tool used for cutting, such as a metallic material.

[0002]

[Description of the Prior Art] The adhesion and the joining phenomenon of high efficiency in recent years, and the antifriction coat and **-ed material covered on a cutting-tool front face in high precision cutting have big effect on cutting-ability ability. namely, current -- sufficient cutting life not only not being acquired by the increment in the frictional resistance which originated in adhesion, a joining phenomenon, etc. with **-ed material in the high degree-of-hardness coat which pursued elevated-temperature properties, such as a mainstream TiAlN coat, and abb-proof RESSHIBU abrasiveness but a cutting side -- it can pluck — degrading process tolerance according to a phenomenon *** — etc. — a technical problem occurs. By the way, it is known that the property which was excellent in a sliding property and compatibility with a processed material, and a CrN coat has a lubrication action as a result, and was excellent in surface treatment, such as metal mold, is shown. Then, the example which applied the lubricity of this CrN coat to the cutting tool is indicated by JP,11-156992,A and Patent Publication Heisei No. 505573 [11 to] as an attempt which solves said technical problem. Moreover, there is JP,7-150337,A as an example which BN was made intermingled and has improved the abrasion resistance of a CrN coat.

[0003]

[Problem(s) to be Solved by the Invention] However, a coat degree of hardness will not be enough, and the compressive stress which remains in a coat will not have abrasion resistance enough for the bottom of a cutting environment severer than a very low thing, either, and the coat exfoliation by the heat crack will produce a CrN coat. Especially in wet cutting, heat-resistant crack nature is very bad, and the coat destruction or exfoliation by the heat crack arises. This invention controls the increment in the frictional resistance resulting from adhesion, a joining phenomenon, etc. with **-ed material in view of such a situation, and let it be a technical problem to offer the covering cutting tool which adopted the adhesion-proof coat which the anomalous attrition by coat exfoliation and the heat crack does not produce.

[0004]

[Means for Solving the Problem] the covering cutting tool which covered the enveloping layer to which the summary of this invention becomes a cutting-tool base from one layer or a multilayer — setting — at least one layer (NbB 1-x (CrAs1-a)) of this enveloping layer — however, it is the covering cutting tool characterized by being the CrSi system film which comes out, and consists of $0.7 \leq a \leq 1$, $0.4 \leq x \leq 1$, and chemical composition shown, and contains the nitride phase of Si, and/or the nitride phase of B.

[0005]

[Embodiment of the Invention] The engine performance of a cutting tool becomes very good, without producing coat exfoliation under severe cutting environments, such as high-speed-cutting processing, by adopting such a configuration, it becomes clear that the precision of a workpiece improves remarkably, and it came to solve the technical problem of the conventional technique. Although the alloying element of the optimum dose to Cr nitride of the CrSi system film demonstrates the outstanding engine performance, when Cr content becomes less than [70at%] at the rate of an atomic ratio of a metal component, a cutting property is not not only fully acquired, but into Cr nitride, Si or B dissolves too much, a coat becomes very weak, and the adhesion-proof engine performance falls. From this, addition of Si to the CrSi system film is less than [30at%]. Moreover, it is necessary to make the addition of B to the inside of Cr nitride into less than [of a nonmetal component / 60at%] from the reduction in friction, and a wear-resistant viewpoint. In addition, on these specifications, B is treated as a nonmetal component.

[0006] It is very effective to add Si and/or B in Cr nitride, and to make Si nitride phase or the nitride phase of B intervene in Cr nitride as a means to improve the abrasion resistance of Cr nitride and heat-resistant crack nature. As a result of observing the CrSi system film concerning this invention in a detail with a transmission electron microscope, it checked that this nano crystal distributed the nitride phase of this Si, or the nitride phase of B to CrN Aiuchi who is an about 20nm nano crystal, has fcc structure and grows in the shape of a column. This nano crystal generates a lattice strain and it is thought that the coat was formed into the high degree of hardness, and the wear-resistant remarkable improvement accomplished according to the dispersion-strengthening device, without raising the residual compression stress in a coat moderately, and degrading adhesion-proof nature. Furthermore, control of the heat crack in wet cutting, and since it acts effectively also in the severer formation of a cutting

environment of high-speed-cutting processing etc. further, this moderate residual compression stress enables stable cutting. Especially mediation of the nitride phase of Si has contributed to the improvement in wet cutting greatly. Furthermore, it contributes to the further low friction-ization of Cr nitride, and the nitride of B could pluck the cutting side, it controls the reattachment of a phenomenon or a workpiece and came to improve the processing side remarkably.

[0007] The above-mentioned CrSi system film has static and the case where cutting-ability ability sufficient in a single coat is not shown to the **-ed material which has high degrees of hardness, such as temper material, although it has the adhesion and low friction which were excellent under the dynamic condition. Then, although it is necessary to use together the film which has the outstanding abrasion resistance and oxidation resistance, the TiAl system film which contains N few as a nonmetallic element including Ti and aluminum at least as a metallic element is the optimal as this film. It becomes possible to obtain the covering cutting tool corresponding to high speed cutting by adopting this. It becomes possible by carrying out the one or more layer laminating of the TiAl system film and the CrSi system film by turns, respectively to obtain the covering cutting tool corresponding to high speed cutting. Since especially adhesion with the CrSi system film is excellent by the adhesion improvement approach according to claim 3, the TiAl system film complements the property of the CrSi system film, and it not only has oxidation resistance and abrasion resistance with sufficient balance, but it demonstrates the engine performance to the maximum extent. Although it is desirable at this time that it is in the maximum upper layer of hard anodic oxidation coatings as for the CrSi system film, even if it is not necessarily the maximum upper layer, that effectiveness is fully demonstrated.

[0008] Furthermore, by setting to 0.98 thru/or 1.02 the value of the ratio of the lattice constant computed from the X diffraction of each (111) field of this TiAl system film and this CrSi system film, the grid mismatching between the atoms of the CrSi system film and the TiAl system film decreases, consequently improvement in remarkable adhesion is shown. This value is a value which **(ed) the lattice constant computed from the field (111) of the TiAl system film with the lattice constant computed from the field (111) of the CrSi system film usually formed by right above [of it]. If the lattice constant computed from the field (111) of the TiAl system film and the CrSi system film is within the limits which is 0.412nm thru/or 0.420nm, respectively, the value of the ratio of the above-mentioned lattice constant will more specifically be satisfied. It became what this reduces the grid mismatching between the atoms of the CrSi system film and the TiAl system film, the film interface reinforcement of the TiAl system film and the CrSi system film improves remarkably, and interfacial peeling stops arising consequently, and shows improvement in remarkable adhesion. In order to depend greatly also as the adjustment approach of this lattice constant on membrane formation conditions, it is necessary to adjust suitably so that it may become the target lattice constant. Although it is bias voltage as an effect--mainly parameter, a side with comparatively low energy is right above [of the TiAl system film] desirable. -30—200V more specifically have good bias voltage. That is, high adhesion is obtained by applying this bias before and after the change of the membrane type in a membrane formation process.

[0009] Since the CrSi system film in this invention may not demonstrate engine performance sufficient as a tool even if it uses it independently like ****, it is necessary to prepare separately the film with which abrasion resistance and oxidation resistance are compensated, and it needs to use it together. Although it explains using this below since it is thought that the TiAl system film well-known as this film is the optimal at present, it is not necessary to necessarily use the TiAl system film together in implementation of invention concerning claim 1 of this application.

[0010]

[Example] What is necessary is just to use the approach by the following, for example in membrane formation by the arc ion plating method, although the PVD represented by the ion plating method, the sputtering method, etc. is mentioned as an approach of forming said CrSi system film concerning this invention in a base front face. After performing evacuation for the inside of a furnace to 3×10^5 Pa first, the defecation and activation of a base by Ar are performed. Then, it is obtained by carrying out ion plating of Cr, Si, and B which were made to ionize by arc discharge from the cathode which is an evaporation source in N₂ ambient atmosphere. Furthermore, if the target which adjusted the presentation according to the target coat presentation is used, the target coat presentation will be stabilized, and it is *****.

[0011] It depends on the covering conditions at the time of membrane formation for formation of the CrSi system film which very important Si nitride phase or the nitride phase of B distributed in this invention greatly. That is, this invention person thinks that the energy (henceforth ion energy) which the ion which participates in coat formation emits is very important. Since the size of the ion energy at the time of covering is dependent on the bias voltage which carries out a seal of approval to a base, in this invention, a setup of bias voltage is important for it. That is, in the case of -50V of comparatively low bias voltage, Cr atom in the fcc structure of Cr nitride permuted by Si atom or B atom, and Si nitride phase and B nitride phase which became independent in Cr nitride were not checked. That is, in order to make the nitride phase of Si, and the nitride phase of B intervene in Cr nitride, it is necessary to form membranes by very high ion energy. Although ion energy is dependent on reaction container internal pressure, an ion kind, etc., in order that these may receive constraint with the engine performance of the coat presentation made into the purpose, or the ion source, there is little room to make it change. Therefore, as a means which raises ion energy, bias voltage is the most effective parameter, about -200—500V is desirable, and if it is this within the limits, the CrSi system film in which the extremely excellent property which Si nitride phase or the nitride phase of B distributed per nano is shown will be easy to be obtained. In addition, it is also an effective means to carry out

minute amount addition of the activity gas components, such as oxygen, into an ambient atmosphere as a means which raises ion energy, and to activate the plasma under arc discharge.

[0012] The result of having measured the binding energy of the compound which exists in drawing 1 – drawing 3 inside this CrSi system film by X-ray photoelectron spectroscopy is shown. Although drawing 1 shows the binding energy in 1S orbit of N, it shows that the nitride which consists of CrN(s) exists. Although drawing 2 shows the binding energy in 2P orbit of Si, association of Si₃N₄ is checked. Association of BN is checked although drawing 3 shows the binding energy of 1S orbit of B. In addition, the binding energy with which the peak concerned expresses was shown all over drawing. In this CrSi system film, it is clearer than drawing 1 – drawing 3 that association of the nitride of Si and the nitride phase of B exists. That is, the binding energy of Cr nitride, Si nitride, and B nitride was checked, and it became clear that Si and B exist as a nitride in Cr nitride.

[0013] When bias voltage is made high, there is an inclination for base temperature to also rise. When temperature is restricted from a demand of the base quality of the material, the cooling means of a base may be needed. Moreover, the amount of generation of Si nitride phase and the nitride phase of B changes with base temperature. According to research of this invention person, with the rise of temperature, the amount of generation decreased, and above 700 degrees C, also when Si nitride phase and the nitride phase of B were not able to be detected, there was. Therefore, I think that 500 degrees C or less of desirable base temperature are 350 degrees C or less more preferably. Although it is not limited especially about the covering approach, when the thermal effect to a covering base material, the fatigue strength of a tool, the adhesion of a coat, etc. are taken into consideration, as for the covering cutting tool of this invention, it is desirable that it is the physical vapor deposition which impresses bias voltage to a covering base side, such as arc discharge method ion plating which can cover with low temperature comparatively, and compressive stress remains to the covered coat, and is excellent in adhesion. Hereafter, this invention is explained based on an example.

[0014]

[Example] Using the arc ion plating system, using N₂ gas which is the various targets made from an alloy which are the evaporation sources of a metal component, and reactant gas, it considered as the covering base temperature of 400 degrees C, and the reagent-gas-pressure force was suitably adjusted so that the target coat might be formed under the conditions of -30—500V in 1x10⁻¹ to 7x100Pa, and bias voltage. To the covering base, using 2 cutting-edge square end mill with an outer diameter of 10mm made from cemented carbide, and R5mm 2 cutting-edge ball end mill made from cemented carbide, membranes were formed so that the thickness of all coats might be set to 4 or 5 micrometers. Membrane formation sequence formed 1.5 micrometers of CrSi system film for the TiAl system film to 2.5 micrometers and a degree first. The lattice constant computed from the field (111) of the nitride contained in the presentation of the CrSi system film of each sample and the TiAl system film and the CrSi system film, *****, the TiAl system film, and the CrSi system film and the value of the ratio are shown in Table 1.

[0015]

[Table 1]

試料番号	TiAl系膜 組成(原子比)	CrSi系膜 組成(原子比)	TiAl系膜 介在化合物	CrSi系膜 格子定数 d_c (nm)	d_r / d_c	スケア エンドミル	ポール エンドミル
					切削長 (m)	切削長 (m)	切削長 (m)
本発明例	1 ($Ti_{50}Al_{50}$)N	($Cr_{98}Si_2$) (N ₈₀ B ₂₀)	Si ₃ N ₄ , BN	0.417	0.415	1.005	90 255
	2 ($Ti_{50}Al_{50}$)N	($Cr_{95}Si_5$) (N ₁₀₀)	Si ₃ N ₄	0.416	0.414	1.005	82 225
	3 ($Ti_{50}Al_{50}$)N	($Cr_{95}Si_{10}$) (N ₇₀ B ₃₀)	Si ₃ N ₄ , BN	0.417	0.416	1.002	91 248
	4 ($Ti_{50}Al_{50}$)N	($Cr_{95}Si_4$) (N ₉₇ B ₃)	Si ₃ N ₄ , BN	0.417	0.417	1.000	93 256
	5 ($Ti_{50}Al_{50}$)N	($Cr_{95}Si_6$) (N ₆₀ B ₃₀)	Si ₃ N ₄ , BN	0.417	0.416	1.002	81 238
	6 ($Ti_{50}Al_{50}$)N	($Cr_{90}Si_{20}$) (N ₉₀ B ₁₀)	Si ₃ N ₄ , BN	0.416	0.414	1.005	80 230
	7 ($Ti_{95}Al_{5}$)N	($Cr_{97}Si_3$) (N ₄₀ B ₂₀)	Si ₃ N ₄ , BN	0.414	0.416	0.995	96 260
比較例	8 ($Ti_{31}Al_{65}Nb_4$)N	($Cr_{95}Si_1$) (N ₈₅ B ₁₅)	Si ₃ N ₄ , BN	0.413	0.415	0.995	95 256
	9 ($Ti_{31}Al_{65}Y_4$)N	($Cr_{95}Si_5$) (N ₉₀ B ₁₀)	Si ₃ N ₄ , BN	0.415	0.416	0.998	94 248
	10 ($Ti_{50}Al_{40}$)N	($Cr_{95}Si_4$) (N ₉₇ B ₃)	Si ₃ N ₄ , BN	0.424	0.411	1.032	71 176
	11 ($Ti_{50}Al_{50}$)N	($Cr_{90}Si_{10}$) (N ₁₀₀)	Si ₃ N ₄	0.417	0.412	1.012	異常摩耗
	12 ($Ti_{50}Al_{50}$)N	($Cr_{95}Si_{15}$) (N ₃₀ B ₇₀)	Si ₃ N ₄ , BN	0.416	0.412	1.010	異常摩耗
	13 ($Ti_{50}Al_{50}$)N	($Cr_{75}Si_{25}$) (N ₉₀ B ₁₀)	—	0.416	0.413	1.007	66 155
	14 ($Ti_{50}Al_{50}$)N	(Cr_{100}) (N ₁₀₀)	—	—	—	—	68 剥離 クラック
	15 (Ti_{100}) (N)	—	—	—	—	—	32 89
	16 ($Ti_{50}Al_{50}$)N	(Ti_{100}) (CN)	—	—	—	—	55 132
	17 (Ti_{100}) (CN)	—	—	—	—	—	48 112
	18 ($Ti_{50}Al_{50}$)N	—	—	—	—	—	52 剥離
	19 ($Ti_{50}Al_{50}$)N	MoS(スパッタ)	—	—	—	—	剥離
	20 ($Ti_{50}Al_{50}$)N	WC/C(スパッタ)	—	—	—	—	剥離
	21 ($Ti_{50}Al_{50}$)N	DLC(スパッタ)	—	—	—	—	36 剥離

[0016] Moreover, it adjusted so that it might become the presentation and lattice constant which were indicated to Table 1 also in the membrane formation conditions of the example of a comparison. In addition, in Table 1, although the display of a presentation wrote the metal component and the nonmetal component by the atomic ratio so that it might be set to 100 in all, respectively, this does not mean that the atomic ratio of a metal component and a nonmetal component is 1:1. The cutting trial was performed using the obtained covering end mill. The tool made [cutting impossible or the cut precision of a processing side] the tool life the length of cut when deteriorating remarkably by a chip or wear of the edge of a blade etc. A cutting item is shown below.

[0017] The cutting item of the square end mill made from two-sheet cutting-edge cemented carbide was taken as side-face cutting, down cutting, **-ed material S50C (HB [220]), amount Adof slitting 10 mmxRd1mm, cutting speed 250 m/min, 0.06mm of delivery and a cutting edge, and the Ayr blow use.

[0018] The cutting item of the ball end mill made from two-sheet cutting-edge cemented carbide is down cutting, **-ed material S50C (HB [220]), and amount Adof slitting 0.2 mmxPick. It considered as Feed0.2mm, engine-speed

10000min⁻¹, table feed-per-revolution 4000 mm/min, and water-soluble cutting fluid use.

[0019] Although the example 2 of this invention is the case where B has not been added on the CrSi system film, as compared with the example 11 of a comparison, a length of cut is long. Although Si is 0.5 atom % and ultralow volume, as for the example 3 of this invention, it turns out that the cutting-ability ability which was excellent to the example 14 of a comparison is shown. Although the length of cut was equivalent as the addition of B was made [many], although the example 5 of this invention did 50 atom % addition of B, the deficit arose in the example 12 of a comparison made into 70 atoms %. Although the example 6 of this invention does 20 atom % addition of Si, as compared with the example of this invention, a life is long. Although the examples 8 and 9 of this invention were examples of this invention at the time of adding Nb or Y on the TiAlN film, the cutting-ability ability which was excellent as compared with the example of this invention was obtained. Although 1.02 which results 0.98 has [the example 10 of this invention] the value out of range which **(ed) the lattice constant computed from the field (111) of the TiAl system film with the lattice constant computed from the field (111) of the CrSi system film and the example of a coat in case a coat presentation and detection compound of the CrSi system film are this invention within the limits is shown although the length of cut became short a little and it entered compared with the example sample numbers 1-9 of this invention, if it compared with the conventional coat, it was markedly alike and the long length of cut was obtained.

[0020] As mentioned above, since the examples 1-10 of this invention are using together the CrSi system film and TiAl system film which reduced remarkably the resistance to friction at the time of cutting, and took into consideration the balance of the adhesion force with hard anodic oxidation coatings, hardness, and toughness without the anomalous attrition resulting from adhesion or a joining phenomenon advances -- moreover, a heat crack -- also receiving -- the outstanding property is shown, and the tool life improved remarkably synthetically, and degradation of the process tolerance of the cutting side by adhesion or the joining phenomenon is controlled, and it came to improve the conventional technical problem greatly. The coat of this invention is suitable for a ball end mill, especially the ball end mill used with wet. Also in the cutting tool which exists variously, finish-machining is performed by the machining allowance with it, and cutting-ability ability is greatly influenced in the ball end mill with which the finishing precision of a workpiece is demanded by the heat crack at the time of cutting, such as adhesion, joining, etc. on the front face of a tool, etc. [strong and intermittence and] [minute] Moreover, in the configuration from which cutting speed changes continuously [a ball end mill etc.], in addition to the heat crack at the time of this cutting, it becomes minute [a cutting allowance for machining], and a sliding property is also required near cutting speed zero. Like the above, it is clear that these properties' [especially] it is the property demanded in an end mill.

[0021] To these, the examples 11 and 12 of a comparison were cases with more additions of Si and B in the CrSi system film than a generic claim, adhesion-proof nature and its joining-proof nature were not enough, and the anomalous attrition by adhesion generated them. Although the example 13 of a comparison is the ratio of the lattice constant of the coat presentation in this generic claim and the CrSi system film, and the TiAl system film, it is an example of a comparison in case the compound of Si₃N₄ and BN does not intervene in the CrSi system film, and is short as compared with the example of this invention. [of a life] Although the example 14 of a comparison is the case where an element is not added to Cr, the coat exfoliation by the heat crack occurs and it cannot demonstrate sufficient property. Although the example of a comparison, and 15, 16, 17, 18, 19, 20 and 21 showed the cutting-ability ability in the hard anodic oxidation coatings to the former, they brought a result in which all are remarkably inferior as compared with the example of this invention.

[0022]

[Effect of the Invention] like the above, since [/ the adhesion and low friction which were excellent compared with the covering cutting tool to the former], in the further high-speed-cutting processing, it is markedly alike, a long tool life is acquired, and the covering cutting tool of this invention is very effective in improvement in the productivity in cutting.

[Translation done.]